UNIVERSITI PUTRA MALAYSIA

SIMULATION OF INTERNET APPLICATIONS OVER GENERAL PACKET RADIO SERVICE

ZUBEIR İZARUKU DAFALLA

SIMULATION OF INTERNET APPLICATIONS OVER GENERAL PACKET RADIO SERVICE

By

ZUBEIR IZARUKU DAFALLA

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Partial Fulfilment of the Requirements for the Degree of Master of Science

August 2002

DEDICATIONS

This thesis is dedicated to my late son Dalil

Abstract of the thesis submitted to the Senate of Universiti Putra Malaysia in partial fulfilment of the requirements of the degree of Master of Science

SIMULATION OF INTERNET APPLICATIONS OVER GPRS

By

ZUBEIR IZARUKU

August 2002

Chairman: Associate Professor Borhanuddin Mohd. Ali, Ph.D.

Faculty: Engineering

The General Packet Radio Service (GPRS) has been designed as an evolutionary step towards the migration from 2nd Generation Wireless Communication Systems to 3rd Generation Wireless Communication systems. The major challenges in GPRS are on its ability to offer lower access delay, better data throughput and radio resource utilization compared to the existing cellular networks. And also on how GPRS can be implemented on the existing cellular networks with little impact on the existing voice services.

This thesis examines the performance of the GPRS Air Interface through simulation. A GPRS network simulator was developed in OPNET™. Performance is judged in terms of Access Delay, Throughput, Point-to-Point delay and Radio Resource utilization over GPRS Network. Some Internet services (e.g. WWW, E-mail and FTP), which are expected to be the most commonly used applications over GPRS are evaluated. The results show that for small number of users in a cell, the access delay in GPRS is small compared to that of GSM and does not depend very much on the number of radio resources allocated for GPRS Service.

GPRS offers higher data throughput than that of traditional Circuit Switched GSM where the maximum data rate per a physical channel is 9.6 Kb/s. However, the data throughput in GPRS become much less than that of GSM under high traffic load. When eight physical channels on a TDMA frame are used for GPRS under good channel conditions, the theoretical data throughput for the GPRS according to ETSI, is supposed to be 171 Kb/s. But our simulation results show that it is very difficult to achieve this kind of throughput due to signaling, protocol overhead the dynamic nature of the wireless channel that changes its state from good to bad resulting into retransmissions thereby reducing the overall throughput. These results could be useful for Radio Network Planners in implementing GPRS on the existing cellular Networks.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian daripada keperluan ijazah Master Sains.

SIMULASI APLIKASI INTERNET ATAS GPRS

Oleh

ZUBEIR IZARUKU

Ogos 2002

Pengerusi: Profesor Madya Borhanuddin Mohd. Ali, Ph.D.

Fakulti: Kejuruteraan

General Packet Radio Service (GPRS) telah direkacipta sebagai langkah evolusi dalam migrasi sistem komunikasi wayarles generasi kedua kepada sistem komunikasi wayarles generasi ketiga. Cabaran utama dalam GPRS adalah kebolehannya mengurangkan kelewatan capaian, memberi truput data yang lebih tinggi, dan penggunaan sumber radio yang lebih baik berbanding dengan rangkaian selular yang sedia ada. Cabaran lain ialah bagaimana GPRS boleh juga dilaksanakan atas rangkaian selular yang sedia ada dengan kesan yang minima terhadap perkhidamatan suara.

Tesis ini memeriksa prestasi antara muka udara GPRS melalui simulasi. Sebuah simulator rangkaian GPRS dibina dengan OPNET™. Prestasinya dikaji dari segi kelewatan capaian, truput, kelewatan titik ke titik dan penggunaan sumber radio atas rangkaian GPRS. Beberapa perkhidmatan Internet (contohnya WWW, E-mel dan FTP), yang dijangka aplikasi yang paling biasa digunakan atas GPRS telah dinilaikan. Keputusannya menunjukkan bahawa untuk bilangan pengguna yang kecil di dalam satu sel,

kelewatan capaian dalam GPRS adalah kecil, berbanding dengan GSM, dan tidak terlalu bergantung kepada bilangan sumber radio yang diperuntukkan untuk perkhidmatan GPRS.

GPRS menawarkan truput data yang lebih tinggi berbanding dengan truput daripada sistem Berpaling Litar GSM, dimana kadar data yang maksima bagi setiap saluran fizikal adalah 9.6Kb/s. Bagaimanapun, truput data GPRS menjadi kurang daripada GSM semasa beban trafik meningkat. Apabila lapan saluran fizikal atas satu birai TDMA digunakan untuk satu pengguna GPRS di bawah keadaan saluran yang baik, truput data secara teorinya yang sepatutunya diperoehi untuk pengguna GPRS mengikut ETSI adalah 171Kb/s. Bagaimanapun, keputusan simulasi kita menunjukkan bahawa ia adalah sukar untuk mencapai truput ini disebabkan oleh pengisyaratan, overhed protokol dan sifat dinamik saluran wayarles yang boleh menyebabkan penghantaran semula. Keputusan ini berguna kepada perancang rangkaian radio dalam melaksanakan GPRS atas sistem selular yang sedia ada.

ACKNOWLEDGEMENTS

Praise be to Allah, the Lord of the Universe, He Who taught man the use of the pen and He taught him what he knew not.

My sincere appreciation and gratitude to some individuals who have immensely contributed to the successful completion of this academic achievement.

I sincerely acknowledge the perfect supervision, advice and devotion of my supervisory committee chairman and supervisor, Assoc. Prof. Dr. Borhanuddin Mohd. Ali and for giving me interesting project to work on. His guidance, constructive criticisms and ever presence for consultation enabled me produce this valuable outcome.

Special valuations are extended to the members of my supervisory committee; Puan Nor Kamariah Noordin, for the encouragement and advice I received from her. My sincere valuations to Dr. Veeraraghavan Prakash, for his continuous help and advice during this study.

I would also like to register my gratitude to Dr. Mohammed Hadi Habaebi for his dedication, recommendations, encouragement and support of any kind during this work.

My sincere thanks to Dr. Sabira Khatun and Ashraf Gassim Sid Abdalla for any kind of advice and help I received from them.

I thank Islamic Development Bank (IDB) for having supported me during this study.

My sincere thanks to Broad Band Research group colleagues in UPM who made my stay in the group very interesting.

I would like to thank my wife Tuna Rajab and daughter Hiba Chandiru for having given me very strong support and encouragement while contacting this study.

Lastly but not least, I would like to thank my father Ahmed and mother Hawa for having given me inspiration for studies right from my childhood.

I certify that an Examination Committee met on 15th August 2002 to conduct the final examination of Zubeir Izaruku Dafalla on his Master of Science thesis entitled "Simulation of Internet Applications over General Packet Radio Service" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Act 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

ABDUL RAHMAN RAMLI, Ph.D,
Lecturer,
Faculty of Engineering,
Universiti Putra Malaysia.
(Chairman)

BORHANUDDIN MOHD. ALI, Ph.D,
Associate Professor,
Faculty of Engineering,
Universiti Putra Malaysia.
(Member)

NOR KAMARIAH NOORDIN,
Lecturer,
Faculty of Engineering,
Universiti Putra Malaysia.
(Member)

VEERARAGHAVAN PRAKASH, Ph.D,
Lecturer,
Faculty of Engineering,
Universiti Putra Malaysia.
(Member)

SHAMSHER MOHAMAD RAMADILI, Ph.D.
Professor/Deputy Dean,
School of Graduate Studies,
Universiti Putra Malaysia

Date: 10 SEP 2002

This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for degree of Master of Science. The members of Supervisory Committee are as follows:

BORHANUDDIN MOHD. ALI, Ph.D,
Associate Professor,
Faculty of Engineering,
Universiti Putra Malaysia.
(Chairman)

NOR KAMARIAH NOORDIN,
Lecturer,
Faculty of Engineering,
Universiti Putra Malaysia.
(Member)

VERARAGHAVAN PRAKASH, Ph.D,
Lecturer,
Faculty of Engineering,
Universiti Putra Malaysia.
(Member)

AINI IDERIS, Ph.D.
Professor/Dean,
School of Graduate Studies,
Universiti Putra Malaysia

Date:

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted in any other degrees in UPM or other institutions.

ZUBEIR IZARUKU DAFALLA

Date: 4/9/2002

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AMPS	Analog Mobile Phone System
AUC	Authentification Centre
BS	Base Station
BSC	Base Station Controller
BSS	Base Station Subsystem
BTS	Base Transceiver Station
CFU	Call Forwarding Unconditional
CPDN	Cellular Packet Data Network
EIR	Equipment Identity Register
ETSI	European Telecommunications Standards Institute
FDMA	Frequency Division Multiplexing
GGSN	Gateway GPRS Support Node
FTP	File Transfer Protocol
GMSC	Gateway MSC
GPRS	General Packet Radio Service
GSM	Global System Of Mobile Communications
HLR	Home Location Register
HTTP	Hypertext Transfer Protocol
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Subscriber Identity
ISDN	Integrated Services Digital Network
LA	Location Area

LLC	Logical Link Control
MAC	Medium Access Control
MS	Mobile Station
MSC	Mobile Switching Centre
MSISDN	Mobile Subscriber Isdn
IID	Independent & Identical Distributed
OSPF	Open Shortest Path Fast Protocol
IP	Internet Protocol
PACCH	Packet Access Control Channel
PAGCH	Packet Access Grant Channel
PBCCH	Packet Broadcast Control Channel
PCCCH	Packet Common Control Channel
PDN	Public Data Network
PDP	Packet Data Protocol
PDTCH	Packet Data Traffic Channel
PLMN	Public Land Mobile Network
PNCH	Packet Notification Channel
PSTN	Public Switched Telephone Network
PRACH	Packet Random Access Channel
PTP-CLNS	Point-To-Point Connectionless Network Service
PTM	Point To Multipoint
PTP-CONS	Point-To-Point Connection Oriented Network Service
QoS	Quality Of Service
RLC	Radio Link Control
SGSN	Serving GPRS Support Node
SIM	Subscriber Identity Module

SMS	Short Message Service
TDMA	Time Division Multiplexing
TMSI	Temporary Mobile Subscriber Identity
TPAL	Transport Protocol Adaptation Layer
UDP	User Datagram Protocol
VLR	Visitor Location Register
WWW	World Wide Web

CHAPTER 1

INTRODUCTION

1.1 Background

This chapter introduces the subject of this study. It sheds light on the important and basic areas of the research. It provides information on the background of the study, statement of research, motivations, research objectives, scope and limitations.

1.2 Overview on General Packet Radio Service (GPRS)

The General Packet Radio Service (GPRS) is a new bearer service for GSM that greatly improves and simplifies wireless access to packet data networks, e.g., to the Internet. It applies a packet radio principle to transfer user data packets in an efficient way between mobile stations and external packet data networks [1].

The impressive growth of cellular mobile telephony as well as the number of Internet users promises an exciting potential for a market that combines both innovations: cellular wireless data services. There is an extensive demand for wireless data services. In particular, high-performance wireless Internet access is requested by users. Existing cellular data services do not fulfill the

needs of users and providers. From the user's point of view, data rates are too slow and the connection setup takes too long and is rather complicated. Moreover, the service is too expensive for most users. From the technical point of view, the drawback results from the fact that current wireless data services are based on circuit switched radio transmission. At the air interface, a complete traffic channel is allocated for a single user for the entire call period. In case of bursty traffic (e.g., Internet traffic), this results in highly inefficient resource utilization. It is obvious that for bursty traffic, packet switched bearer services result in a much better utilization of the traffic channels. This is because a channel will only be allocated when needed and will be released immediately after the transmission of the packets. With this principle, multiple users can share one physical channel (statistical multiplexing) [2].

In order to address these inefficiencies, two cellular packet data technologies have been developed: Cellular Digital Packet Data (CDPD) (for AMPS, IS-95, and IS-136), and the General Packet Radio Service (GPRS) (both developed for GSM but GPRS is being integrated to IS-136).

GPRS applies a packet radio principle to transfer user data packets in an efficient way between GSM mobile stations and external packet data networks. Packets can be directly routed from the GPRS mobile stations to packet switched networks. Networks based on the Internet Protocol (IP) (e.g., the global Internet or private/corporate intranets) and X.25 networks are supported in the current version of GPRS. Users of GPRS benefit from shorter access times and higher data rates. In conventional GSM, the

connection setup takes several seconds and rates for data transmission are restricted to 9.6 kbit/s. The proposed GPRS in practice is supposed to offer session establishment times below one second and ISDN-like data rates up to several ten kbit/s. In addition, GPRS packet transmission is to offer a user-friendlier billing than that offered by circuit switched services. In circuit switched services, billing is based on the duration of the connection. This is unsuitable for applications with bursty traffic. The user must pay for the entire airtime, even for idle periods when no packets are sent (e.g., when the user reads a Web page). In contrast, with packet switched services, billing can be based on the amount of transmitted data. The advantage for the user is that he or she can be "online" over a long period of time but will be billed based on the transmitted data volume [3].

1.3 Motivations

There are over three hundred GSM service providers around the world with a very large subscriber base. While GSM subscriber base continues to increase, the demand for high-speed wireless data services also increases since the traditional GSM systems in addition to using circuit switching mechanism, cannot offer data rates beyond 9.6 kbit/s. GPRS technology which uses packet switching is meant to increase the data transmission rates to several kbit/s and this will also help these second-generation wireless

systems remain in the very competitive market of wireless communication and gradually migrate to third generation systems.

This research will therefore evaluate the performance of GPRS technology. Different service applications (e.g., WWW, FTP and E-mail services), which will be the most widely used applications over GPRS network. The results can be used as guidelines to help GSM service providers in implementing GPRS on their network. It will also enable the service providers to predict what data rates and access delay are experienced by the end user.

1.4 Objectives

The Objectives of this thesis are as follows:

- To study the performance of GPRS air interface in terms of access delay, end-to-end delay and throughput by using Internet Applications such as HTTP (WWW), FTP and E-mail services through simulation.
- To study the effect of a given load of users on channel capacity and utilization at the Base Transceiver Station.